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UNITED STATES DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS
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Letter
Circular
LC-502A

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STRUCTURAL PROPERTIES OF LOW-COST HOUSE CONSTRUCTION

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I. GENERAL

The objectives, procedure, and scope of the research program on building materials have been outlined in Letter Circular LC-502. This circular describes the test procedure to be used in determining the structural properties of walls, partitions, floors, and roofs. These elements of a house will be subjected in the laboratory to loads simulating those which occur in service and the strength and other structural properties determined.

Laboratory tests to determine the structural properties of elements can be made at a reasonable cost of time and money. It is hoped that a standardized test procedure can be developed which will give a reasonable basis for evaluating the merits of new constructions, and that new constructions of good performance and low cost may be developed in cooperation with the building industry. For the present, tests will be made only on constructions which cost less than the amounts given in Table 1 as of July 1937 and fabricated or delivered in Washington, D. C.

Table 1 -- Maximum Cost of Constructions included in Program

Element	Maximum cost per sq ft
Bearing walls	$0.60
Partitions and non-bearing walls	.35
Floors, structural, finish, and ceiling below	.75
Roof, structural, covering above and ceiling below	.60

These costs are liberal and high enough to include constructions suitable for low-cost apartment constructions. Constructions intended for free-standing houses in suburban or rural districts should cost much less. The chief interest is in constructions costing much less than these maximum figures.

II. SPECIMENS

The specimens tested shall be duplicates of portions of a completely finished house.

The width of specimens of floors, wall, etc. shall be a multiple of the spacing of the principal members such as joists, studs, etc. The specimen shall be symmetrical about a longitudinal center.

The number and description of the specimens required for each element are as follows:

Walls

15 specimens, length 8 ft, nominal width 4 ft.
3 specimens, length 8 ft, nominal width 8 ft.

Partitions

3 specimens, length 8 ft, nominal width 4 ft.

Floors

6 specimens, length 12 ft 6 in., nominal width 4 ft.

For panels prefabricated in definite widths and fastened together after the panels are in place, 3 specimens, length 2 ft fastened together as in service.

Roofs

3 specimens, length 14 ft 6 in., nominal width 4 ft.

The specimens for walls and partitions may include specimens having doors and windows but these specimens shall be in addition to those without doors and windows.

For each element the different loads under service conditions were estimated and the program of tests prepared to include those which appeared of fundamental importance. Additional tests for some constructions undoubtedly will be necessary.

The procedure for each test will be similar. Uniform load increments will be applied and the deformation measured except for the concentrated load. After the application of each load increment, the set, i.e. permanent set or residual deformation, will be measured.

From the deformation and set readings, load-deformation and load-set graphs will be drawn. The maximum load that the specimen will sustain will be determined. This load may be either the load causing the specimen to rupture or the load after which the deformation increases continuously under smaller loads.

The program of tests follows:-

III. WALLS

1. Compressive Load

(a) Specimen:- Length 8 ft, nominal width 4 ft. Number of specimens 3.

(b) Test conditions:- See Fig. 1. A column having a flat end at the bottom , compressive load applied to a steel plate covering the top of the specimen. The load shall be applied uniformly along a line parallel to the inside face and one-third the thickness of the wall from the inside face.

(c) Readings:- Shortening and set for equal load increments; maximum load.

2. Transverse Load

(a) Specimen:- Length 8 ft, nominal width 4 ft, number of specimens 6.

(b) Test conditions:- See Fig. 2. A beam simply supported. Span 7 ft 6 in. Two equal loads applied uniformly along two transverse lines each one-fourth the span from a support. For three specimens, the load shall be applied to the outside face of the wall and for three specimens to the inside face of the wall.

(c) Readings:- Deflection and set at mid span for equal load increments; maximum load.

3. Concentrated Load

(a) Specimen:- A portion of the transverse specimen III 2(a) after test.

(b) Test conditions:- One face of the specimen resting on a horizontal rigid plate. A steel disc having a diameter of one inch and the lower edge rounded to a radius of 0.05 inch shall be placed on the upper face of the specimen at what is considered the weakest place. A load shall be applied downward on the upper surface of the disc. The disc shall be placed first on one face of the specimen and then on the other face.

(c) Readings:- The indentation in the face of the specimen after removal of the disc for equal load increments; maximum load.

4. Impact Load

(a) Specimen:- Length 8 ft, nominal width 4 ft, number of specimens 6.

(b) Test conditions:- See Fig. 3. A beam simply supported. Span 7 ft 6 in. Impact load applied at the middle of the face of the specimen by a sand bag weighing 60 lb and having a diameter of 10 in. For three specimens the impact load shall be applied to the outside face of the wall and for three specimens to the inside face of the wall.

(c) Readings:- Set at mid span for equal increments in height-of-drop; height-of-drop at rupture, provided the height-of-drop does not exceed 10 ft.

5. Racking Load

(a) Specimen:- Length 8 ft, width 8 ft, number of specimens 3.

(b) Test conditions:- See Fig. 4. The bottom edge of the specimen shall be secured to a rigid horizontal support and a load parallel to the support shall be applied to the top of the specimen at one end. This end of the specimen shall be restrained against lifting from the support.

(c) Readings:- The detrusion and set (horizontal displacement of the top of the specimen with respect to the bottom) for equal load increments.

IV. PARTITIONS, NON-LOAD BEARING

1. Impact Load

(a) Specimen:- Length 8 ft, nominal width 4 ft, number of specimens 3.

(b) Test conditions:- See Fig. 3. A beam simply supported. Span 7 ft 6 in. Impact load applied at the middle of the face of the specimen by a sand bag weighing 60 lb and having a diameter of 10 in.

(c) Readings:- Set at mid span for equal increments in height-of-drop; height-of-drop at rupture provided the height-of-drop does not exceed 10 ft.

2. Concentrated Load

(a) Specimen:- A portion of the impact specimen IV 1(a) after the impact test.

(b) Test conditions:- One face of the specimen resting on a horizontal rigid plate. A steel disc having a diameter of one inch and the lower edge rounded to a radius of 0.05 inch shall be placed on the upper face of the specimen at what is considered the weakest place. A load shall be applied downward on the upper surface of the disc.

(c) Readings:- The indentation in the face of the specimen after removal of the disc for equal load increments; maximum load.

V. FLOORS

1. Transverse Load

(a) Specimen:- Length 12 ft 6 in., nominal width 4 ft, number of specimens 3.

(b) Test conditions:- See Fig. 2. A beam simply supported. Span 12 ft. Two equal loads applied uniformly along two transverse lines each one-fourth of the span from a support. The loads shall be applied to the upper surface of the floor.

(c) Readings:- Deflection and set at mid span for equal load increments; maximum load.

2. Concentrated Load

(a) Specimen:- A portion of the transverse specimen V 1(a) after the test.

(b) Test conditions:- The lower surface of the floor resting on a horizontal rigid plate. A steel disc having a diameter of one inch and the lower edge rounded to a radius of 0.05 inch shall be placed on the upper surface of the floor at what is considered the weakest place. A load shall be applied downward to the upper surface of the disc.

(c) Readings:- The indentation in the surface of the specimen after the removal of the disc for equal load increments; maximum load.

3. Impact Load

(a) Specimen:- Length 12 ft 6 in., nominal width 4 ft, number of specimens 3.

(b) Test conditions:- See Fig. 3. A beam simply supported. Span 12 ft. Impact load applied at the middle of the upper surface of the floor by a sand bag weighing 60 lb and having a diameter of 10 in.

(c) Readings:- Deflection and set at mid span for equal increments in height-of-drop; height-of-drop at rupture provided the height-of-drop does not exceed 10 ft.

4. Shearing Load on Joint

This property will be determined only for floor panels which are prefabricated in definite widths and which are fastened together after the panels are in place.

(a) Specimen:- Two panels, each 2 ft long, fastened together as in service. Number of specimens 3.

(b) Test conditions:- See Fig. 5. One panel shall be supported at both edges and the outside edge of this first panel shall be restrained against moving upward. The outside edge of the second panel shall be supported. Two equal loads shall be applied uniformly on the second panel along two transverse lines each one-fourth the panel width from the panel edges.

(c) Readings:- For equal load increments, the set (vertical displacement) of the edge of the second panel relative to the edge of the first panel; maximum load.

VI. ROOFS

1. Transverse Load

(a) Specimen:- Length 14 ft 6 in., nominal width 4 ft, number of specimens 3.

(b) Test conditions:- See Fig. 2. A beam simply supported. Span 14 ft. Two equal loads applied uniformly along two transverse lines each one-fourth the span from a support. The loads shall be applied to the upper (weather resistant) surface of the roof.

(c) Readings:- Deflection and set at mid span for equal load increments; maximum load.

2. Concentrated Load

(a) Specimen:- A portion of the transverse specimen VI 1(a) after test.

(b) Test conditions:- One surface of the specimen resting on a horizontal rigid plate. A steel disc having a diameter of one inch and the lower edge rounded to a radius of 0.05 inch shall be placed on the upper (weather resistant) surface of the roof at which is considered the weakest place. A load shall be applied downward on the upper surface of the disc.

(c) Readings:- The indentation in the surface of the specimen after removal of the disc for equal load increments; maximum load.

VII. MINIMUM REQUIREMENTS

In order to limit the tests to constructions which are likely to be useful in the building of houses, the following procedure will be used. Constructions will first be examined with respect to what appears

to be their weakest points. If the performance does not comply with certain minimum requirements, no further tests will be made. Thus if the weak points appear to be structural, the structural properties will first be determined. Those constructions which comply with the minimum requirements for structural properties given in this circular may then be studied further with respect to other properties such as fire resistance, thermal insulation, etc. Particular attention can then be given to the durability or service life. Restricting further study to constructions which do not exceed the maximum cost and which comply with the minimum requirements will very greatly reduce the number of constructions which it will be necessary to study further.

Minimum requirements for what appeared to be the most important structural properties have been prepared, based on the greatest loads applied to each element of a house under very favorable service conditions. These requirements are intended solely as a guide in the selection of constructions for further study, and are not intended for use in building codes or in the actual construction of houses. The establishment of minimum requirements for building codes and for building houses depends on a consideration of the different service conditions to which houses are subjected, as well as a consideration of the type of house, single, row, or apartment.

It must be clearly understood that no claim is made that a construction complying with these minimum requirements will prove satisfactory. The tests will give sufficient data to determine whether the construction complies with any requirements that may be determined necessary for a specific application.

The minimum requirements for the various elements which must be met to warrant further study are as follows:

1. Walls, compressive load

(a) Definition:- (A) walls are walls for one-story and for the top story of houses having more than one story. (B) walls are walls for houses having one story above the (B) walls.

Requirements for (A) Walls

(b) Set:- The set after the application of a load of 320 lb/ft of width shall not exceed 0.096 in. (1/1000 height).

(c) Maximum load:- The maximum load shall be not less than 640 lb/ft of width.

Requirements for (B) Walls

(d) Set:- The set after the application of a load of 960 lb/ft of width shall not exceed 0.096 in. (1/1000 height).

(e) Maximum load:- The maximum load shall be not less than 1920 lb/ft of width.

2. Walls, transverse load.

(a) Set:- The set after the application of a load of 20 lb/ft^2 shall not exceed 0.090 in. (1/1000 span) and windows and/or doors shall operate satisfactorily.

3. Walls, concentrated load.

(a) Indentation:- The indentation after the application of a load of 100 lb shall not exceed 0.1 in.

4. Walls, impact load.

(a) Set:- For a height-of-drop of 2.5 ft the set shall not exceed 0.090 in. (1/1000 span).

5. Walls, racking load.

(a) Set:- The set after the application of a load of 1920 lb shall not exceed 0.096 in. (1/1000 height).

6. Partitions, impact load.

(a) Set:- For a height-of-drop of 2.5 ft the set shall not exceed 0.090 in. (1/1000 span).

7. Partitions, concentrated load.

(a) Indentation:- The indentation after the application of a load of 100 lb shall not exceed 0.1 in.

8. Floors, transverse load.

(a) Deflection:- The deflection under a load of 40 lb/ft^2 shall not exceed 1.44 in. (1/100 span).

(b) Set:- The set after the application of a load of 40 lb/ft^2 shall not exceed 0.144 in. (1/1000 span).

(c) Maximum load:- The maximum load shall be not less than 80 lb/ft^2.

9. Floors, concentrated load.

(a) Indentation:- The indentation after the application of a load of 100 lb shall not exceed 0.05 in.

10. Floors, impact load.

(a) Set:- For a height-of-drop of 2.5 ft the set shall not exceed 0.144 in. (1/1000 span).

11. Floors, shearing load on joint.

(a) Set:- The set after the application of a load of 40 lb/ft^2 shall not exceed 0.05 in.

12. Roofs, transverse load.

(a) Set:- The set after the application of a load of 20 lb/ft^2 shall not exceed 0.168 in. (1/1000 span).

(b) Maximum load:- The maximum load shall be not less than 40 lb/ft^2.

13. Roofs, concentrated load.

(a) Indentation:- The indentation after the application of a load of 100 lb shall not exceed 0.1 inch.

VIII. COOPERATION WITH INDUSTRY

Interested industrial groups are invited to cooperate in the program by designing, constructing, and supplying specimens to be included in the program. It is not the desire of the Bureau to publicize constructions which are unsatisfactory but to cooperate with the industry in developing satisfactory constructions of low cost. Attention is again called to the fact that the specimen should be a complete part of a house from exterior finish to interior finish.

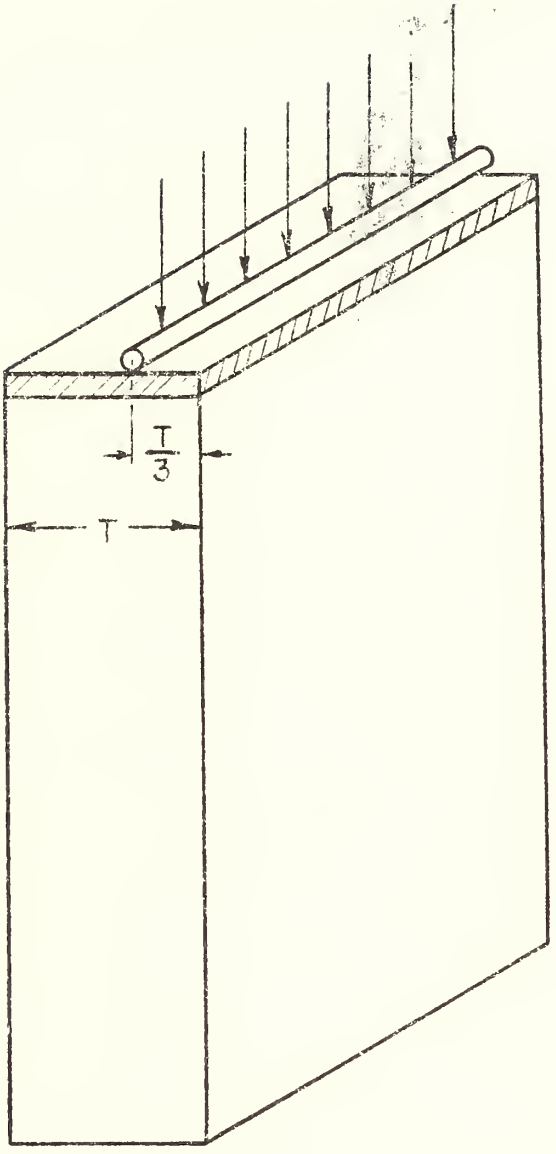

FIG. 1

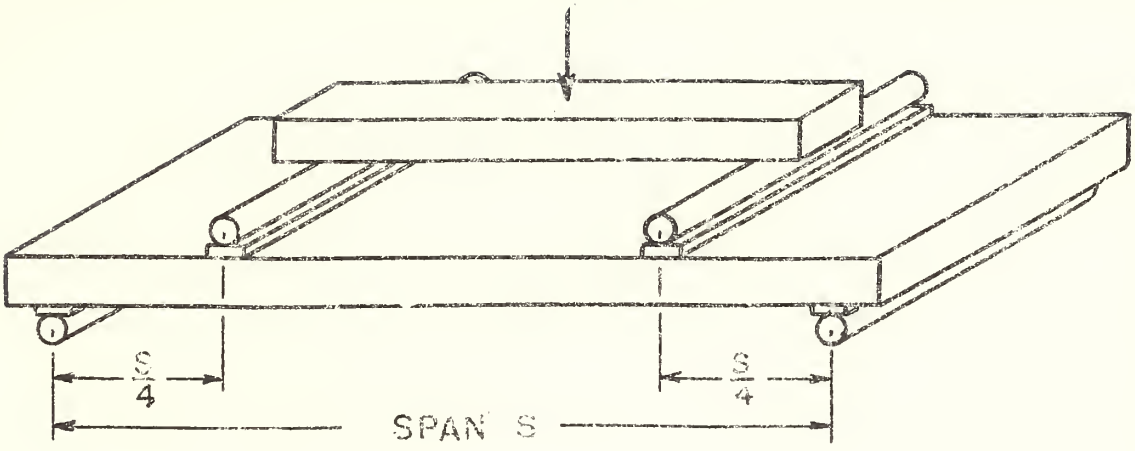

FIG. 2

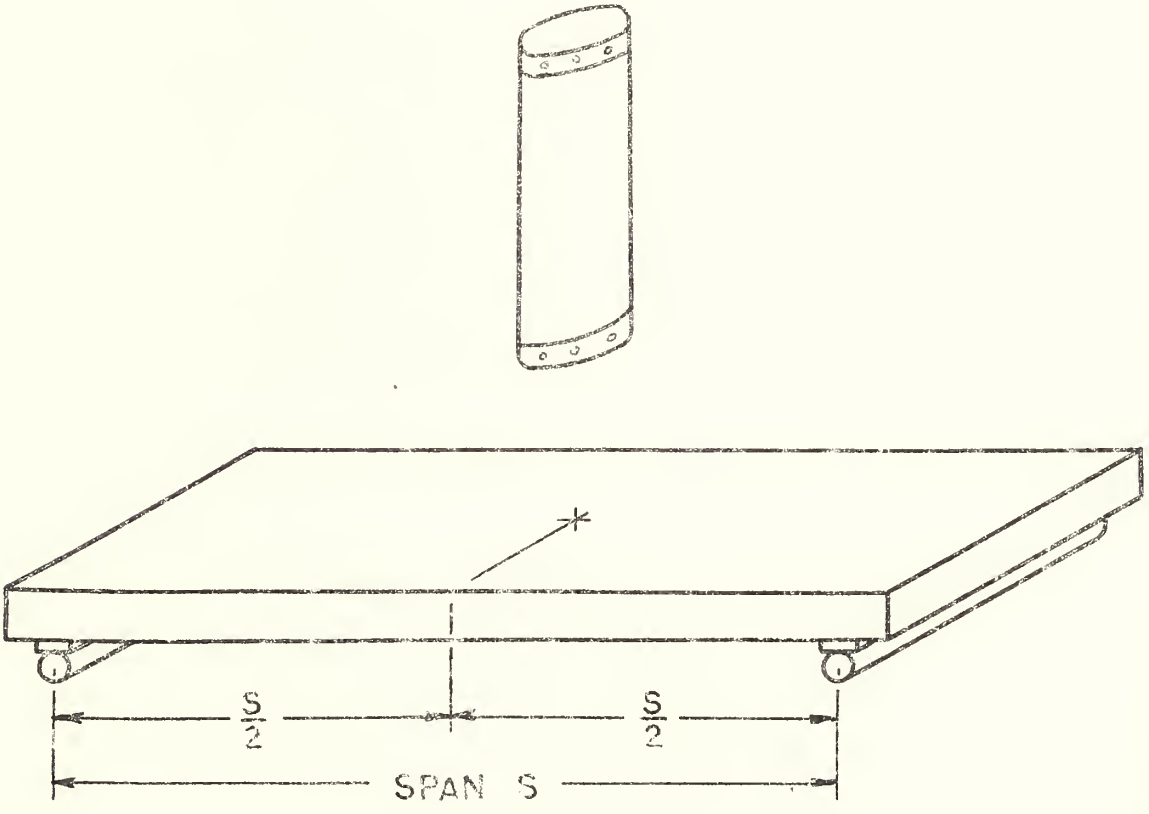

FIG. 3

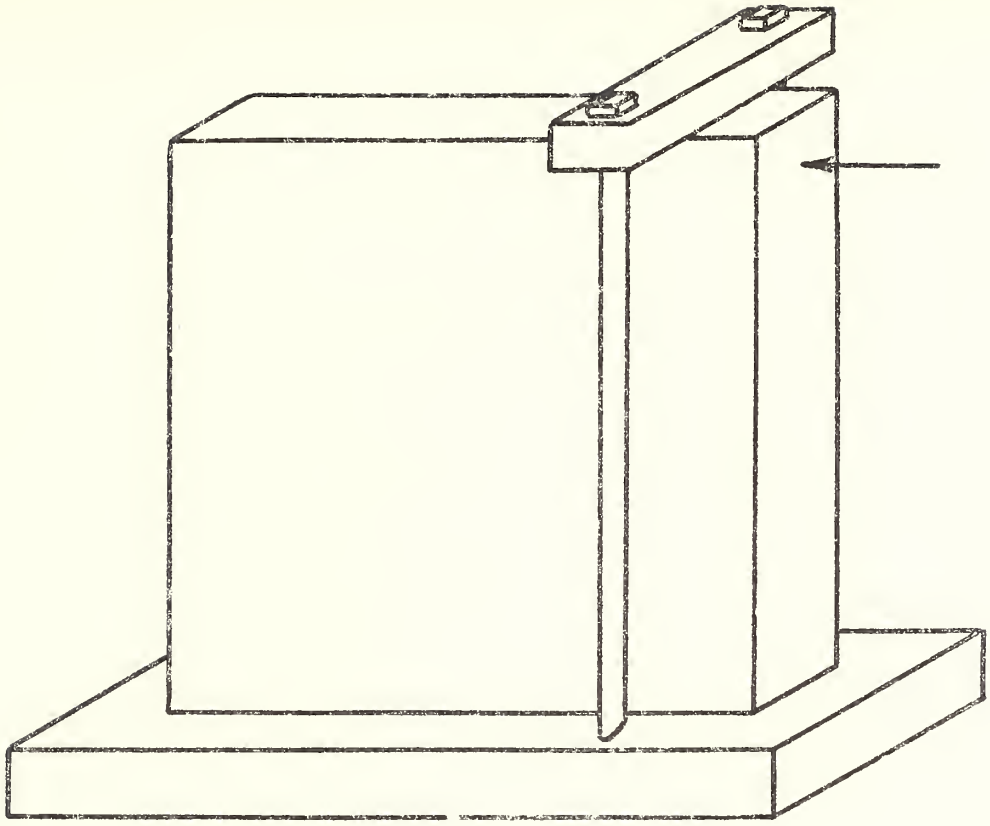

FIG. 4

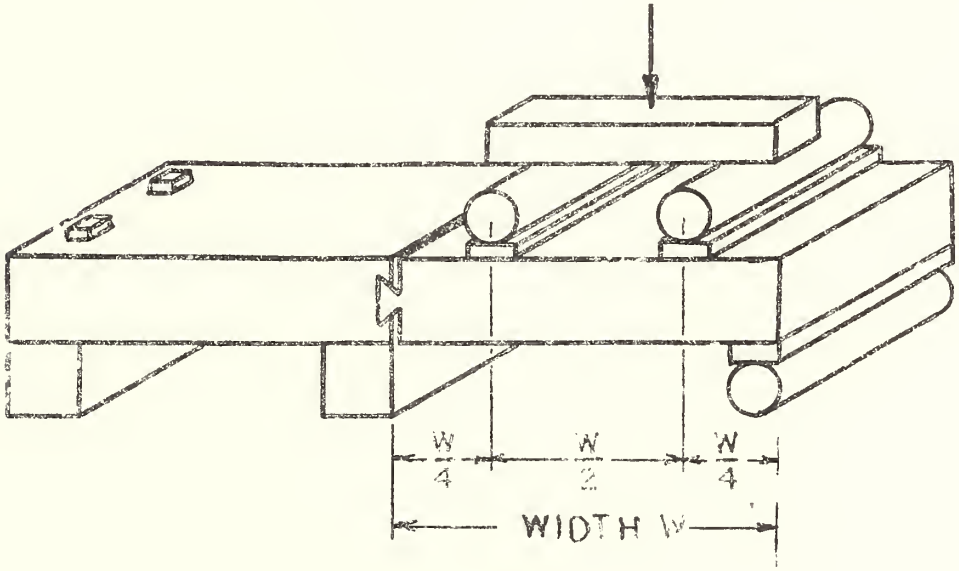

FIG. 5